A scenario for the formation of dwarf galaxies with an anomally low dark-matter content

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Abstract. The formation and evolution of a low mass galaxy in the gravitational field of a massive disk galaxy (like the Milky Way) has been studied. Numerical simulations of complex gas-dynamic flows are based on our own variant of the Chemo–Dynamical Smoothed Particle Hydrodynamical (**CD–SPH**) approach, which incorporates star formation. The dynamics of the dark matter was treated as a standard N–body problem. It is shown that the satellite galaxy effectively looses its dark matter component due to the strong tidal influence of the massive galaxy, while the gas, owing to its strong dissipative nature, forms an almost dark-matter–free dwarf galaxy.

1 Method

Dwarf galaxies are the most dominant population of the present–day Universe [5]. In the standard cold dark matter model low–mass galaxies are considered to be the first luminous objects. If the present dwarfs are dark matter dominated, they could account for a significant fraction of the mass of galaxy clusters. Besides their numerosity, dwarfs seem to be the simplest galactic system available for reliable observational study and theoretical modelling.

The hydrodynamical simulations are based on our own variant of the Chemo–Dynamical Smoothed Particle Hydrodynamics (**CD–SPH**) approach, including feedback through star formation phenomena. The dynamics of the dark matter component are treated within a standard N–body approach. Thus, the satellite galaxy consists of dark matter, gas and "star" particles. For a detailed description of the **CD–SPH** code (the star formation algorithm, the SNII, SNIa and PN production, and the chemical enrichment) the reader is referred to [1,2]. It is to be noted that the code was slightly modified for the present problem so as to include the photometric evolution of each "star" particle, based on the idea of the Single Stellar Population (SSP) [3,6]. At each time-step, absolute magnitudes: M_U, M_B, M_V, M_R, M_I, M_K, M_M and M_{bol} are defined separately for each "star" particle. The SSP integrated colours (UBVRIKM) are taken from [6] (Table 2). The spectro–photometric evolution of the overall ensemble of the "star" particles forms the Spectral Energy Distribution (SED) of the satellite.

2 Model parameters

The central host galaxy is assumed to be a Milky-Way–like system. It is modelled as a Disk + Bulge + Halo system according to [4].

The initial satellite proto-galaxy is taken to be a gas–rich and dark matter dominated proto–dwarf with a total mass $M_{SAT} = 2 \cdot 10^9\ M_\odot$ and an initial radius $R_{SAT} = 5$ kpc. The baryonic (i.e. initial "gas") mass of the proto–dwarf is $M_{SAT}^{gas} = 2 \cdot 10^8\ M_\odot$, and the initial Dark-Matter (DM) mass is $M_{SAT}^{dm} = 1.8 \cdot 10^9\ M_\odot$. Initially the centre of the proto–dwarf is located at Galactocentric coordinates (0, 0, 150 kpc). The initial velocity field of this object is defined as the sum of the orbital motion in the host galaxy in the polar plane (YZ) and the rotation around its own rotational axis (parallel to the X axis of host galaxy). The initial velocity of orbital motion is: $V_y = 75$ km/sec. The dimensionless angular velocity vector of the rotation is $\mathbf{\Omega} = (1, 0, 0)$. As the system unit for this physical parameter we use the value: $\Omega_0 = \sqrt{G \cdot M_{SAT}/R_{SAT}}/R_{SAT}$.

3 Results

Extensive numerical simulation show that model evolution results in the formation of a baryon-dominated satellite galaxy. The basic process keeping this scenario is the dissipative nature of the baryonic component of the proto–dwarf, which easily forms a compact structure with a radius smaller than the tidal radius. The practically dissipationless dark-matter component forms an extended structure which is effectively destroyed via tidal influence of the massive galaxy. This mechanism is very interesting in the context of the possible existence of of dSph galaxies with a low dark-matter content.

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